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TRACEABILITY PROJECT

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TIIVISTELMÄ

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Opinnäytetyö keskittyy Wärtsilän kiertokankiverstaalla pilotoitavaan Jäljitettävyyshankkeeseen. Opinnäytetyön pääpainona on Unique Item Identifier – koodien sijoittaminen kiertokankiverstaan tuotteisiin. Lisäksi opinnäytetyöhön sisältyy koodien lukemiseen ja kaivertamiseen käytettävien välineiden valinnat sekä työntekijöiden kouluttaminen Jäljitettävyyshankkeesta aiheutuneita uusia työtehtäviä varten.

Jäljitettävyyshankkeeseen on meneillään oleva globaali projekti Wärtsilässä. Projektin päätavoitteena on kyetä parantamaan asiakastytytyvääisyyttä sekä hallita Wärtsilän sisäisiä ja ulkoisia riskejä jäljittämällä tarkemmin Wärtsilän käyttämiä ja tuottamia materiaaleja, kappaleita ja kokoonpanoja.

Jäljittäminen suoritetaan laittamalla tuotteisiin jäljitettävyysherkintä, UII-koodi, joka pystytään lukemaan matriisikoodien lukulaitteella. Tällä tavoin tietoa kerätään, varastoidaan ja hallinnoidaan Wärtsilän tietokannoissa.

Projektin arvioidut hyödyt ovat parannettu tarkkuus tuotteiden takaisinvedossa, alkuperäisten Wärtsilä-osien erottaminen kopioista sekä parempi asema epäselvissä takuutilanteissa.

ABSTRACT

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This thesis focuses on Traceability Project at Wärtsilä's Connecting Rod Factory. The main emphasis is on the placements of the Unique Item Identifiers on Connecting Rod Factory's products, on the equipment used with traceability to read and mark the UIIs and on the training of the employees for the new work tasks created by Traceability Project.

The Traceability Project is a global, ongoing project at Wärtsilä. The main goal of the project is to provide better customer experience and to better control Wärtsilä's internal and external risks by tracing materials, parts and products made and used by Wärtsilä.

Tracing of the products is executed by placing Unique Item Identifiers onto Wärtsilä's products. The codes are then read with Matrix Code Readers to gather, store and manage the information in Wärtsilä's databases.

The biggest benefits from the project are improved accuracy at recalling defective products, identifying original Wärtsilä components from replicas, better standing in unclear warranty situations and increased supply chain efficiency.

Keywords	Traceability, Connecting Rod Factory, Unique Item Identifier, Wärtsilä
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APPENDIX 1. [CLASSIFIED.]

APPENDIX 2. [CLASSIFIED.]

APPENDIX 3. Material Structure Trees at Connecting Rod Factory

GLOSSARY

UII	Unique Item Identifier, the main component of Traceability Project, includes a Data Matrix and text string to contain manufacturing information.
EPC	Engineering, Procurement and Construction, EPC Contractor carries out the engineering, equipment and material procurement and construction of the project for their customer.
W20	Wärtsilä 20 Engine; 20 refers to the diameter of the piston used in the engines.
W32	Wärtsilä 32 Engine; 32 refers to the diameter of the piston used in the engines.
W31	Wärtsilä 31 Engine; 31 refers to the diameter of the piston used in the engines. A new product announced in 2015. Production is still minimal, only a few engines have been made.
Conrod	Short for Connecting Rod.
Conrod Factory	Short for Connecting Rod Factory.
Main Assembly	The name of the factory where the engines are assembled. Other factories inside Wärtsilä provide Main Assembly with the parts they need to assemble the engine.
Piston Module	Finished product produced at Connecting Rod Factory; includes upper part, piston, piston rings, gudgeon pin, gudgeon pin bearing, screws and nuts.
Piston Set	Group of Piston Modules sent forward from Connecting Rod Factory to Main Assembly.

Conrod Module	Finished product produced at Connecting Rod Factory; includes lower parts, screws and big end bearings.
Lower Part Set	Group of Conrod Modules sent forward from Connecting Rod Factory to Main Assembly.
QDMS	Quality Document Management System, used by Wärtsilä to manage quality data on various different products and materials.
SAP	Database program used by Wärtsilä.
MES	Manufacturing Execution System, an upcoming user-interface to SAP database.
FMS	Flexible Manufacturing System, an intelligent manufacturing system that allows for reaction to both predicted and unpredicted changes.

1 INTRODUCTION

This thesis was done for Wärtsilä, a global leader in complete lifecycle power solutions for the marine and energy markets.

The aim of the thesis was to help design and initialize Traceability Project at Wärtsilä's Connecting Rod Factory. Traceability Project has been an ongoing project at Wärtsilä since 2013, and this thesis will help to implement and finalize it at Connecting Rod Factory.

Traceability Project includes designing where and how to insert Unique Item Identifiers (later referred to as UIIs) into Connection Rod Factory's products, planning the layout for equipment that is used to read and link together the UIIs and providing the required training and training material to the designated personnel.

The UII contains the information required for Wärtsilä to properly trace back the origin of the product; information such as manufacturer, batch numbers, material numbers, serial numbers, manufacturing date and number of products in the batch.

The topic of this thesis is important to Wärtsilä as it provides them with the means to trace their products more closely, which helps them identify original Wärtsilä components from false ones, allows them to provide support to their products more efficiently and enables them to recall deficient products with increased accuracy. Traceability also helps Wärtsilä with unclear warranty situations and creates more efficient supply chain. All of the aforementioned benefits affect the quality of Wärtsilä's service, and thus influence the perception of Wärtsilä's clients and potential clients towards them, which affects their revenue. Additionally, the contents of this thesis are intended to be used as a guide for other departments at Wärtsilä in their initialization of Traceability.

2 WÄRTSILÄ OYJ

Wärtsilä is a global leader in complete lifecycle power solutions for marine and energy markets. In 2014, Wärtsilä's net sales totaled EUR 4.8 billion with approximately 17,700 employees. The company has operations in over 200 locations in nearly 70 countries around the world. /1/

2.1 Organization

Wärtsilä's organization is divided into three branches: Marine Solutions, Energy Solutions and Services. Marine Solutions and Energy Solutions were previously known as Ship Power and Power Plants, but as Wärtsilä's product portfolio grew, it was decided to rename them to better describe their function in the company. /2/

2.1.1 Marine Solutions

Marine Solutions offers Wärtsilä's customers with wide array of products for "shorter route to bigger profits". Marine Solutions focuses on environmental products and services, with various different technologies aimed to reduce the environmental footprint of their customers. Their emphasis is on lifecycle efficiency, attempting to minimize both the environmental impact of emissions and the volumes of waste. Marine Solutions aims to satisfy customer needs with the ability to customize their products as the customer sees fit, offering to deliver everything from a single product to a complete lifecycle support of complex systems for powering ships. /2/; /3/; /4/

2.1.2 Energy Solutions

Energy Solutions designs and builds power plants. Aside from designing and building the power plants, Energy Solutions is also a leading EPC contractor that provides their customers with financing, project development and project services.

Wärtsilä Energy Solutions offers Smart Power Generation based on internal combustion engines that run on any liquid or gaseous fuels. Smart Power Generation provides operational flexibility with fast-responding engines, energy efficiency

due to the modular design of multiple cascading engines and fuel flexibility by being able run on any liquid or gaseous fuel, in addition to being able to switch from one fuel to another without stopping. /5/; /6/

2.1.3 Services

Wärtsilä Services offers support for its customers throughout the whole lifecycle of their products and installations. They aim to optimize the efficiency and performance of the customer's products for both Marine and Energy Solutions. Wärtsilä Services provides environmentally sound, high quality support for their customers anywhere in the world.

Services attempts to enhance its customer's business by offering lifecycle efficiency aimed to improve customer's profits by preventing the unexpected, optimizing the performance and improving the environmental efficiency of all of Wärtsilä's installations. /2/; /7/

3 WÄRTSILÄ CONNECTING ROD FACTORY

Wärtsilä Connecting Rod Factory produces connecting rods for W20 and W32 engines (see Figure 1 and Figure 2). The connecting rods are assembled into W20 Piston Modules, W32 Piston Modules and W32 Conrod Modules at the Conrod Factory (see Figure 3 and Figure 4). The Piston Modules are then sent forward in production to the Main Assembly, where they are assembled into Wärtsilä's W20 and W32 engines.



Figure 1. W20 connecting rod.

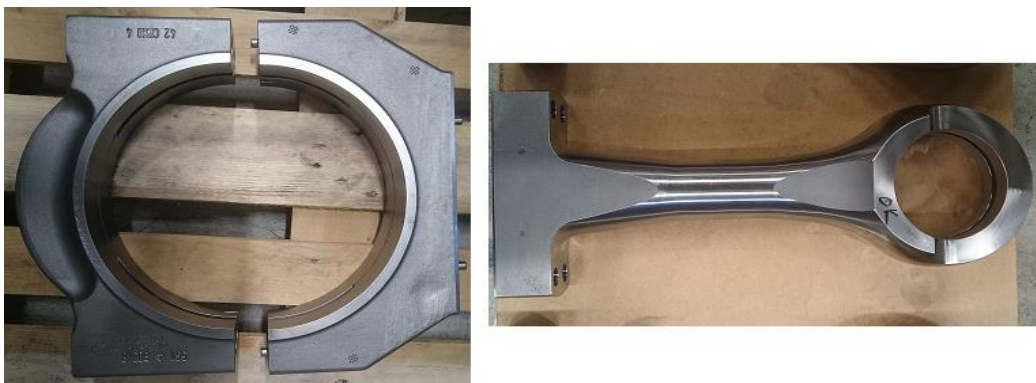


Figure 2. W32 connecting rod. Lower part on the left, upper part on the right.



Figure 3. W20 piston modules in assembly.



Figure 4. W32 piston modules in assembly, gudgeon pins still unattached.

The Conrod Factory is undergoing major changes, as the old production line will be scrapped and replaced by a robotic manufacturing line. The Traceability Project was initialized before the robotic manufacturing line is built, so it was necessary to think the traceability process through for the current and future production lines. The new production line will be deployed in March 2016, while the Traceability Project was first initialized at the Conrod Factory in September 2015.

3.1 Current Production Line

The production is done in two main areas: machining area and assembly area (see Figure 5). The machining area consists of three machining centers, three loading stations, a product elevator, burr removal robot, shot peening machine and two manual finishing stations (see Figure 6). The assembly area consists of magnetic particle inspection, washing machine and two assembly stations (see Figure 7).

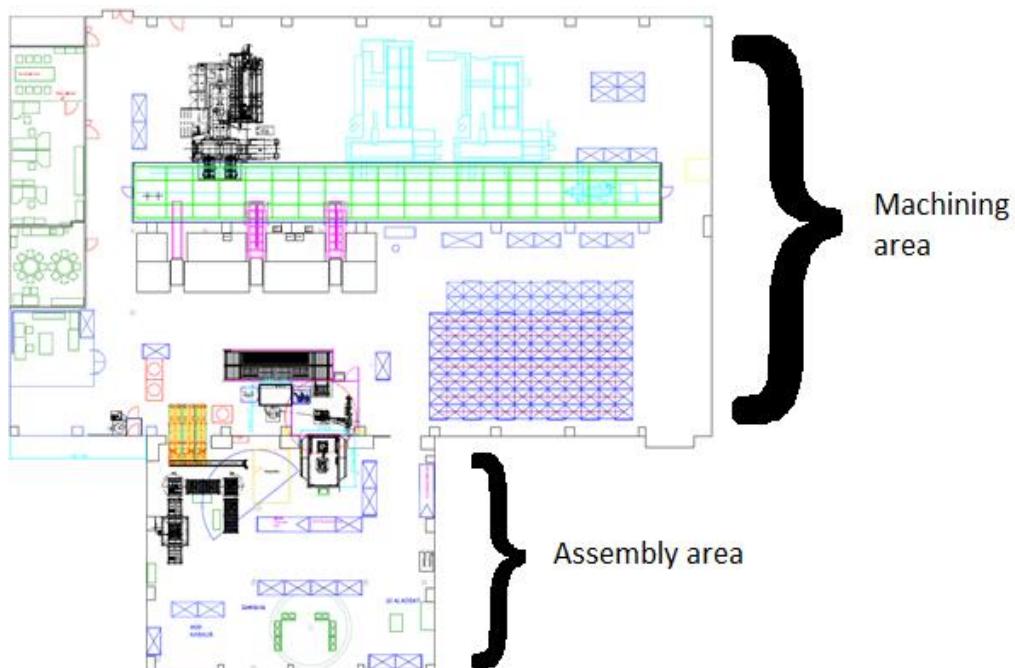


Figure 5. Current Connecting Rod Factory layout.

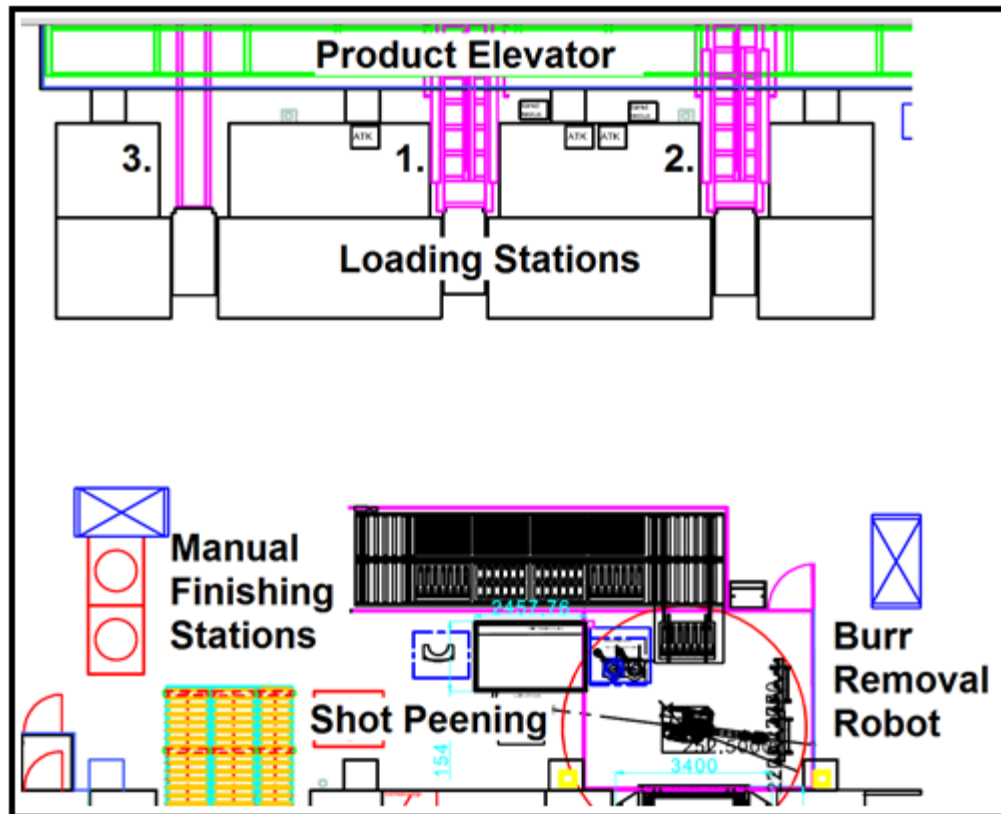


Figure 6. Machining area layout, close-up.

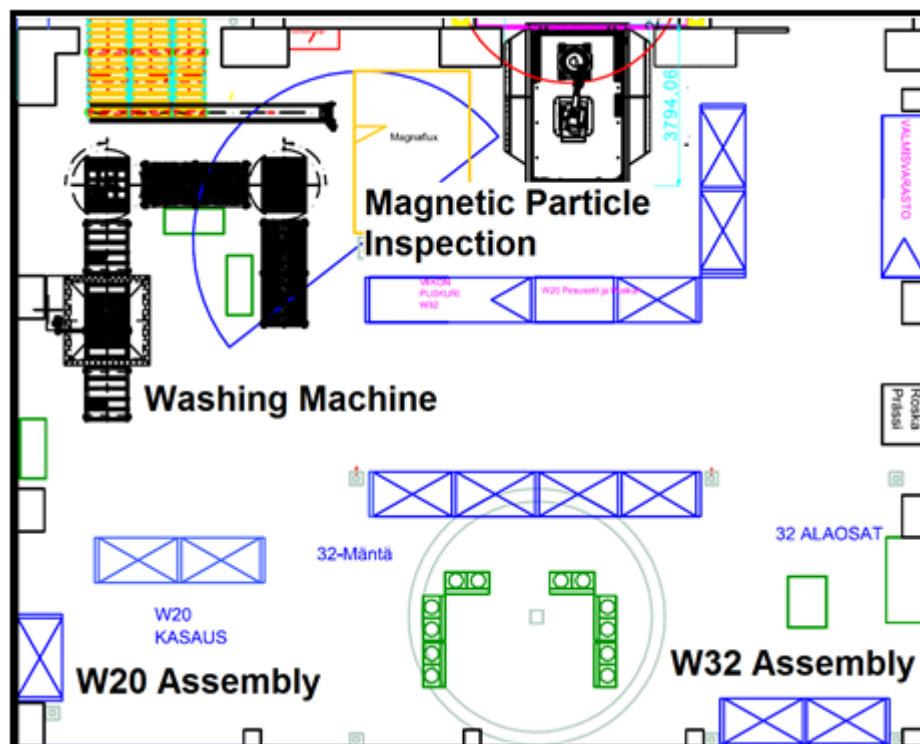


Figure 7. Assembly area layout, close-Up.

3.1.1 W20 Connecting Rod Manufacturing

In the W20 connecting rod manufacturing, the first step is attaching the forging to a machining fixture and sending it to the machining center via the product elevator. The machining process is done in five stages, and between each stage the connecting rod is returned back to the loading station by the product elevator and the position of the connecting rod in the machining fixture is changed.

After each machining stage, the connecting rod is measured, and if everything is within tolerances, it is sent forward in production; to the burr removal robot, where most of the excess burr is removed. After the robotic burr removal, the connecting rod goes through shot peening and manual burr removal, as the robot is unable to remove all burr. During the manual burr removal the connecting rod is visually inspected to ensure the quality of the product.

After the manual finishing station the connecting rods are sent to assembly area, where they are inspected with magnetic particle inspection. There they are put in sets of six connecting rods, washed in the washing machine and while they are still fairly warm from the washing machine, around 60°C, the gudgeon pin bearings are attached. Once the bearings are attached the connecting rods are sent to the W20 assembly cell. At this point the connecting rods are assigned an engine that they will be used for.

Once assembled, the final product is called W20 Piston Module, which includes the connecting rod, bearings, screws and nuts, piston, gudgeon pin and piston rings (see Appendix 3). A group of piston modules sent forward to the Main Assembly from the Conrod Factory is called a Piston Set.

3.1.2 W32 Connecting Rod Manufacturing

The W32 connecting rod consists of an upper part and a lower part. The forging for the upper part is attached to a machining fixture and sent to the machining center via the product elevator. The upper part is machined in one stage.

The lower part consists of two parts: the middle part and the lower part, but as they go through the whole production as a pair, they are only referred to as the lower part. The lower part is machined in three stages. First, the forgings are attached to a machining fixture and sent to the machining center via the product elevator. Between each stage the parts are returned back to the loading station by the product elevator and the position of the parts in the machining fixture is changed. For the last stage of the machining the parts are fastened together.

Once machined, the upper and lower parts are taken to robotic burr removal and shot peening. After those the remaining burr is removed manually and the parts are inspected visually to ensure the quality of the product.

The next step in the production of the upper and lower parts is magnetic particle inspection, after which the products are sent to the washing machine in sets of six. For the upper parts gudgeon pin bearings are attached while they are still warm, around 60°C. From the washing machine both the upper and lower parts are sent to W32 assembly cell. At this point the parts are assigned an engine that they will be used for.

The final products after assembly are called the W32 Piston Module, which includes the upper part, gudgeon pin bearing, screws and nuts, piston, gudgeon pin and piston rings, and the W32 Conrod Module, which includes lower parts, screws and big end bearings (see Appendix 3). When a group of Piston Modules is sent to the Main Assembly from the Conrod Factory it is called a Piston Set, respectively a set of Conrod Modules is called a Lower Part Set.

3.2 Production Orders

Production orders are made and managed in the SAP database. Production orders are essentially reservations of materials for products that will be made. They are opened and closed during various stages of manufacturing to keep track of the amounts of materials for parts, products and assemblies; to keep stock. Opening a production order means that the amount of materials defined in the order are taken from the stock and used for production. Closing the production order moves those

materials in the database to become available for the next step of production. Additionally, opening and closing the production orders leaves a time stamp in SAP for tracing the manufacturing times of the products.

Production orders at the Connecting Rod Factory are opened at:

- The beginning of machining process
- The washing machine before the installation of gudgeon pin bearings
- The assembly during the assembly process

Production orders at the Connecting Rod Factory are closed at:

- The end of machining process
- The washing machine after the gudgeon pin bearings have been installed
- The assembly once the assembly process is finished and the products are ready to be sent out of Connecting Rod Factory.

4 TRACEABILITY

The main goal of traceability is being able to verify the location, history or application of an item. Traceability has many applications across several fields of business. In logistics, traceability is referred to as the capability to trace products in the distribution chain, based on serial numbers or batch numbers. For materials, traceability is the finished part's ability to withstand destructive tests to make sure the material's integrity is up to standard. Traceability can also be used to provide customers with transparency; if the company so wishes, the traceability information can include the entire supply chain of the product, which can be used to prove that the product has been produced in an ethical and environmentally friendly way. /8/

One of the biggest benefits of traceability is making recalls more accurate, which means considerable savings for the company performing the recall. For example, in 2013, Toyota recalled 510 000 vehicles for air bag problem that ended up affecting 170 000 vehicles. If the recall had been more accurate, they could potentially have saved up to 68 million dollars, or 52 million euros with the exchange rate at the time. /9/

Traceability is often carried out by using Unique Item Identifiers to track product information. Product information contained in the UII includes information such as manufacturer, manufacturing periods, batch numbers, revision numbers and production orders. This information is gathered and used to better keep track of product performance in the field. With traceability, it is possible to notice if there is a correlation between two similar products breaking down on the opposite sides of the world. And if there is a correlation, it is possible to recall the deficient parts or products more accurately for repairs.

4.1 Traceability at Connecting Rod Factory

The tracing of products at the Conrod Factory is currently handled via QDMS, where the products used are entered to the system manually during the assembly. The current system is extremely slow and errors during the manual entering are

not unheard of. A lot of the information that will be gathered by the Traceability Project is already being traced at Conrod Factory, but in a slower, more inconvenient way that is liable to errors.

At the Conrod Factory the Traceability Project is executed by including UIIs to track and link the products and assemblies manufactured at the factory. Each part of an assembly is marked with a UII, and the codes included in the UII are used to link the parts together in the SAP database. Reading any of the UIIs in the product is enough to access the full information of all the UIIs linked to the said product. The UII in the product is either temporary or permanent, but the information read from it is saved to SAP database, where it is stored indefinitely.

The UII consists of the Data Matrix Code and a human readable text string. The Data Matrix Codes are read by a matrix code reader, which sends the information to a database where all the information is gathered. Once read, this information can be accessed at any time by a computer, even if the UII is no longer visible in, or attached to, the actual product.

Before traceability can be initialized, the correct equipment must be acquired and optimized for usage, product drawings must be changed to allow for the placement of UIIs, new software must be acquired to allow for printing of the UII codes, old software must be updated to allow the matrix codes to be read, subcontractors must be informed about placing the matrix codes into their products and personnel must be trained to use the new equipment.

The Traceability Project will influence the entire chain of production for all of Connecting Rod Factory's products. It also affects Wärtsilä's subcontractors as they must also adapt to the new requirements set by the Traceability Project.

4.2 Unique Item Identifier Formats

The UII consists of the Data Matrix in the ECC 200 format and a text string in human readable text. The Data Matrix and text string contain the same information. If expressly requested in the Quality Instruction or in the drawing, the

text string can be omitted or shortened. In this case only the Data Matrix in the ECC 200 format shall be marked on the component.

The UIIs defined for purchased parts and in-house production parts are different. The sections for different UII are defined in Chapter 4.2.1 and 4.2.2, and they are divided by a separator character ASCII code 35 (# “Number”). /10/

4.2.1 Unique Item Identifier Format for Purchased Parts

The UII for purchased parts contains a maximum of 35 digits of alphanumeric text string. The UII contains the Vendor, Manufacturing period, Material revision letter, indication whether the part is serialized or if it is made in batch and a serial or batch number (see Figure 8 and Table 1). /10/

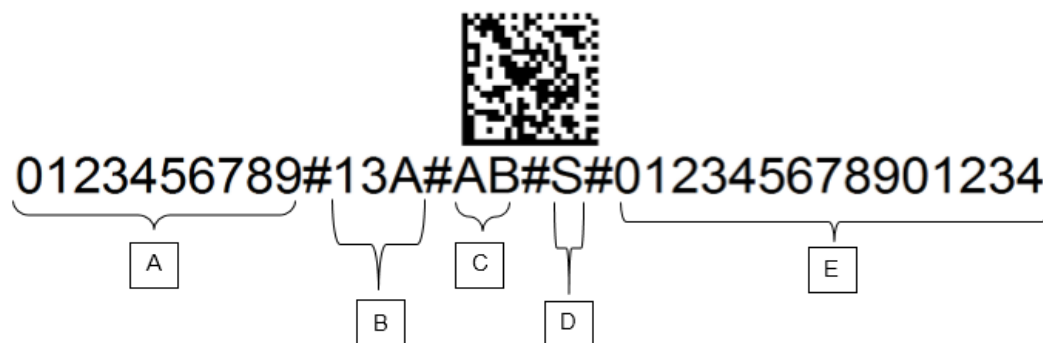


Figure 8. An example of a UII for purchased parts.

Table 1. [CLASSIFIED.]

4.2.2 Unique Item Identifier Format for In-House Parts

The UII for in-house produced parts contains a maximum of 36 digits of alphanumeric text string. The UII contains the Manufacturing factory, Manufacturing period, Production Order number, Incremental quantity of Production Order, Material revision letter and an indication whether the parts are serialized or made in batch. (see Figure 9 and Table 2) /10/



Figure 9. An example of a UII for in-house produced parts.

Table 2. [CLASSIFIED.]

[illegible]

4.3 Required Equipment

The new equipment that Wärtsilä has to acquire includes data matrix readers, sticker printers and marking machine. The selection of equipment was done in collaboration with the project manager of the Traceability Project, purchasing department and the management of the Connecting Rod Factory. The equipment and their properties are presented next.

4.3.1 Data Matrix Readers

Required number: 5

- Product Elevator Loading Zone
- W20 Machining
- Washing Machine
- W20 Assembly
- W32 Assembly

Selected: Cognex DataMan 9500 Series Mobile Computer (see Figure 10).

Pros:

- Wireless
- Good docking station
- Easy to use
- Cheap

Cons:

- Customer support
- Problems if battery runs out
- Hard to setup



Figure 10. Cognex DataMan 9500 Series Mobile Computer.

Alternatives:

Screenless versions of Cognex's data matrix readers were considered, but it was decided that having a screen is more convenient.

Motorola's data matrix readers were considered, but never tried out, because Cognex's device was working as intended.

4.3.2 Sticker Printers

Required number: 2

- Washing Machine
- Assembly Computer

Selected: Zebra ZT410 Sticker Printer (see Figure 11).

Pros:

- Works on multiple materials
- Flexible with different sticker sizes

Cons: Large size



Figure 11. Zebra ZT410 Sticker Printer.

4.3.3 Marking Machines

Required number: 1

- W20 Machining

Selected: Flymarker Pro Hand-Held Marking System with Symbol -data matrix reader (see Figure 12).

Pros:

- Easy to use
- Easy to position the marking
- Wireless
- Great quality of markings
- Flexible to use

Cons:

- Hard to mark on curved surfaces,

- Heavy
- No wireless connection to the data matrix reader



Figure 12. Flymarker Pro Hand-Held Marking System.

4.4 Placement of the UIIs

For every in-house produced component the placement of the UII has to be considered individually, and in a way that it is as convenient as possible for production. For subcontracted components the placement decisions for the UII were, aside from a few exceptions, more restricted due to price, subcontractor working methods and the small size of the components. With this in mind, various different possibilities were considered and the best were selected, tried out and enhanced in collaboration with the workers at the production line.

Traceability has yet to be activated on most of the following parts, but even though the UIIs have not yet been inserted in them, the locations for the UIIs have been chosen.

4.4.1 W20 & W32 Additional Components

Requirements:

- Must be permanent
- Must be visible after installation
- No need for the human readable text string
- Subcontractors need to be able to do the marking

Selected: For screws, nuts, bearings, piston rings and gudgeon pins there were no alternative places to insert the UIIs, as the space to insert the UII in was really limited (see Figure 13, Figure 14 and Figure 15).



Figure 13. The planned UII locations for W20 and W32 screws and nuts.

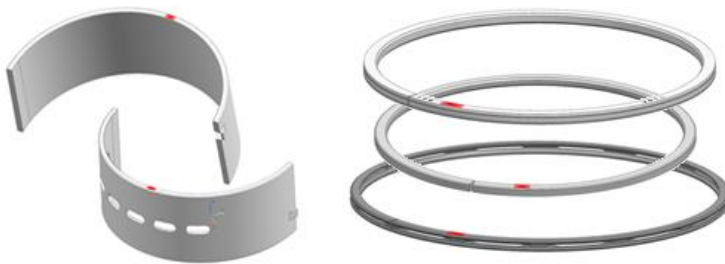


Figure 14. The planned UII locations for W20 and W32 big end bearings and piston rings.



Figure 15. W32 gudgeon pin and W20 gudgeon pin bearing. The planned UII location is the same on W20 gudgeon pin and W32 gudgeon pin bearing.

4.4.2 W20 Connecting Rod Forging

Requirements:

- Must be visible when on a pallet
- Must have two different placements on the connecting rod
 - On the body and on the cap of the connecting rod
- Preferably near the old marking area on the connecting rod
- Preferably permanent

Selected: The UIIs are inscribed with a marking machine by the supplier (see Figure 16).

Pros:

- Permanent
- Does not replace any of the old markings,
- UIIs are easy to read with the data matrix reader

Cons: None

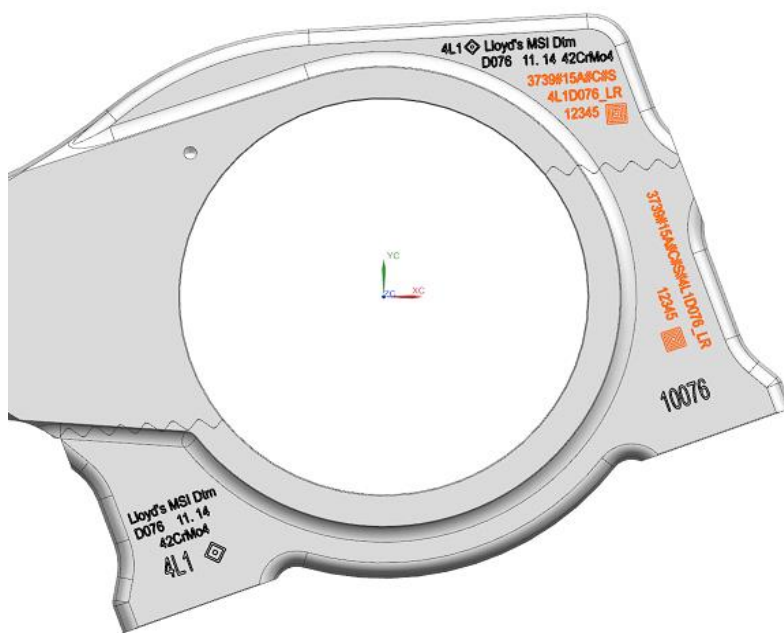


Figure 16. The planned location for W20 Connecting Rod Forging UII.

Alternative: The UII is inscribed with a marking machine by the supplier. The placements are near the old markings on body and cap.

Pros:

- Permanent
- Easy to read with the data matrix reader

Cons:

- Replaces some of the old markings due to space issues.

4.4.3 W20 Connecting Rod Machined

Requirements:

- Must be visible while on a pallet
- Must be marked on both parts of the assembly
- Must be readable when assembled into the engine
- Preferably near the old marking area on the connecting rod

- Does not have to include the entire UII
- Must be permanent

Selected: The UII is manually Dot Peen Marked into both the cap and body of the connecting rod between the second and third stages of machining process (see Figure 17).

Pros:

- Permanent
- Marked on both the cap and body to avoid errors
- Marked early on in the process to ensure that the marking works
 - Even after the product is assembled into engine
- Distinctive placement from Connecting Rod Forging UII

Cons:

- Possible errors hard to fix
- Possible problems with the marking machine



Figure 17. W20 Connecting Rod Machined UII. Test piece for marking machine.

Alternatives:

Dot Peen Marking the UII near Connecting Rod Forging UII

Pros:

- Permanent
- Easy to read during production

Cons:

- The surface already has Connecting Rod Forging UII so the possibility of linking error is large.
- Placement not as distinctive as in the selected placement

4.4.4 W20 Complete Connecting Rod**Requirements:**

- Must withstand heat of 60°C
- Flexible placing between different parts in the same set
 - In production, the conrods are washed in sets of 6 with some components having different facing due to the design of the washing pallet
- Preferably removable

Selected: UII-Sticker attached to a magnetic strip, attached on the machined surface of the connecting rod (see Figure 18).

Pros:

- Cheap
- Easy and fast to attach and remove
- Easy to read with the data matrix reader
- Sticks well
- Can be attached to both sides of the connecting rod
- Leaves no marks when removed

- Does not clutter the finished product with an extra UII

Cons: Possibility that the magnetic strip detaches by accident.



Figure 18. A full pallet of W20 connecting rods with the UII-stickered magnetic strips attached.

Alternatives:

1. Dot Peen Marking the UII

Pros:

- Cannot detach from the surface by accident

Cons:

- Cannot be removed
- Clutters the finished product with an extra UII
- Laborious to insert

2. UII-Sticker directly attached to the surface of the connecting rod

Pros:

- Cheap
- Easy to attach
- Easy to read with the data matrix reader
- Can be attached to both sides of the conrod
- Does not clutter the finished product with an extra UII

Cons:

- Laborious to remove
- Either sticks too well or not well enough
 - Depending on the type of sticker used and the temperature of the product when the sticker is inserted
- Often left marks when removed
- Possibility of the sticker detaching by an accident

3. Printing an A4 paper with all the UIIs and packing it with the connecting rods

Pros:

- Cheap,
- Easy to read with the data matrix reader
- Does not clutter the finished product with an extra UII
- Requires little labour

Cons: Possibility of error during linking process is very large

4.4.5 W32 Upper Part Forging

Requirements:

- Preferably permanent
- Must be readable while on the pallet

- Preferably near the old markings

Selected: Dot Peen Marking the UII. Done by the subcontractor (see Figure 19).

Pros:

- Permanent
- Readable on the pallet
- Easy to read with the data matrix reader

Cons: None

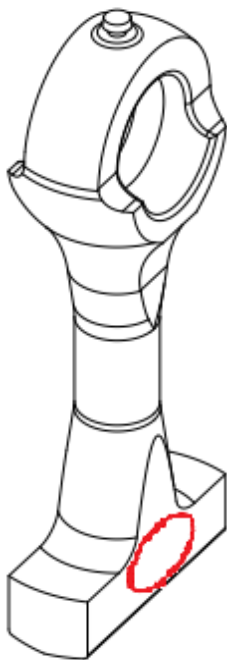


Figure 19. The planned location for W32 Upper Part Forging UII.

4.4.6 W32 Upper Part Machined

Requirements:

- Must be readable while on a pallet
- Must be readable when assembled into the engine
- Preferably near the old marking area on the connecting rod

- Does not have to include the entire UII
- Permanent

Selected: Dot Peen Marking the UII. Done by a robot (see Figure 20).

Pros:

- Permanent
- Little chance of error
- Easy to read with the data matrix reader
- Linking is also done by the robot
- Near the old marking area

Cons:

- Tight space for the marking

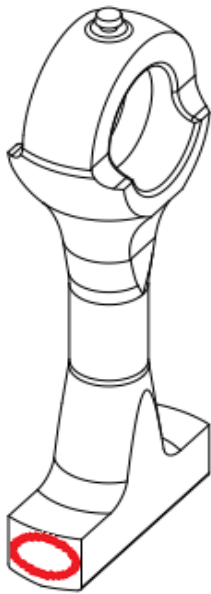


Figure 20. The planned location for W32 Upper Part Machined UII.

4.4.7 W32 Complete Upper Part

Requirements:

- Must withstand heat of 60°C
- Preferably removable

Selected: UII-Sticker attached to a magnetic strip, attached on the surface of the connecting rod (see Figure 21).

Pros:

- Cheap
- Easy and fast to attach and remove
- Easy to read with the data matrix reader
- Sticks well
- Leaves no marks when removed
- Does not clutter the finished product with an extra UII

Cons:

- Possibility that the magnetic strip detaches during assembly



Figure 21. The location for W32 Complete Upper Part UII.

Alternative:

UII-Sticker attached on the surface of the connecting rod

Pros:

- Cheap
- Easy to attach
- Easy to read with the data matrix reader
- Can be attached to both sides of the conrod
- Does not clutter the finished product with an extra UII

Cons:

- Laborious to remove
- Either sticks too well or not well enough
 - Depending on the type of sticker and the temperature of the connecting rod when the sticker is inserted
- Often leaves marks when removed
- Possibility of the sticker detaching by an accident

4.4.8 W32 Lower Part Forging

Requirements:

- Preferably permanent
- Must be readable while on a pallet
- Must be marked on both parts of the assembly
- Preferably near the old marking area on the connecting rod

Selected: The UIIs are inscribed with a marking machine by the subcontractor to both lower and middle parts (see Figure 22).

Pros:

- Permanent

- Readable on the pallet
- Easy to read with the data matrix reader

Cons: None

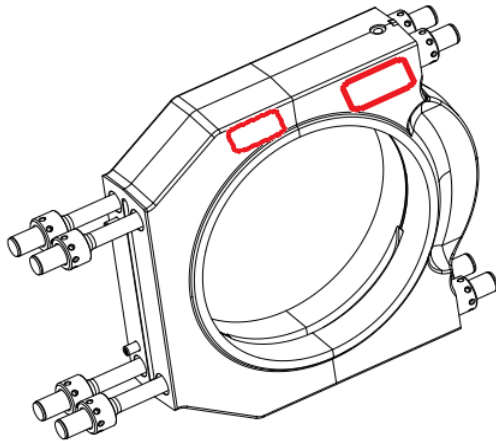


Figure 22. The planned location for W32 Lower Part Forging UII.

4.4.9 W32 Lower Part Machined

Requirements:

- Must be readable while on a pallet
- Must be inscribed on both parts of the assembly
- Permanent

Selected: Dot Peen Marking the UII. Done by a robot (see Figure 23).

Pros:

- Permanent
- Little chance of error
- Easy to read with the data matrix reader
- Linking is also done by the robot
- Near the old marking area

Cons: Tight space for the marking

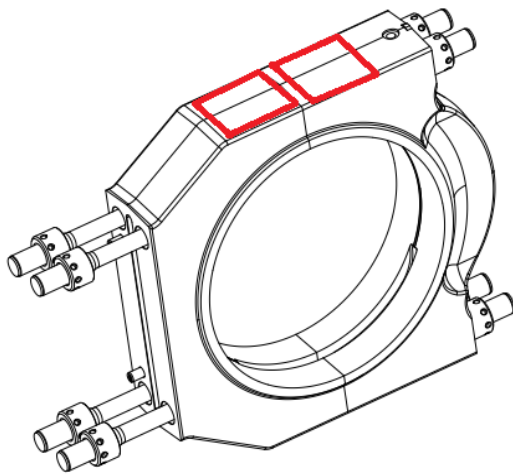


Figure 23. The planned location for W32 Lower Part Machined UII.

4.4.10 W20 & W32 Pistons

Requirements:

- Preferably the upper surface
- Must not be on the lateral surface
- Preferably near the other markings on the Piston
- No need to endure usage
- No need for full UII
- Separate UII for piston skirt and piston head
 - Usually during maintenance only the head of the piston is changed, leaving the old piston skirt in place

Selected: Dot Peen Marking the UII to the top of the piston head and to the top of the piston skirt by the subcontractor. Linking of the piston skirt and piston head is also done by the subcontractor (see Figure 24).

Pros:

- Piston Head UII easy to read during production
- Near the other markings on the piston
- The locations are easy to mark for the subcontractor
- Endures transportation
- Subcontractor takes care of the piston skirt and piston head linking process

Cons:

- The UII can wear out when the piston is in use



Figure 24. The planned location for W20 and W32 Piston UII.

4.4.11 W32 Conrod Module

Requirements:

- Must be easy to read at the W32 assembly cell
- Must endure transportation
- Preferably removable

Selected: UII-Sticker, and a back-up A4 paper with all the Conrod Module UIIs included in the set (see Figure 25).

Pros:

- Easy to insert and remove
- Paper to ensure that UIIs get delivered even if the sticker detaches
- Easy to read with the data matrix reader
- Cheap
- Does not clutter the finished product with an extra UII

Cons:

- Sticker might prove unreliable
 - The forging surface could prove to be non-adhesive due to the rough surface of the forging

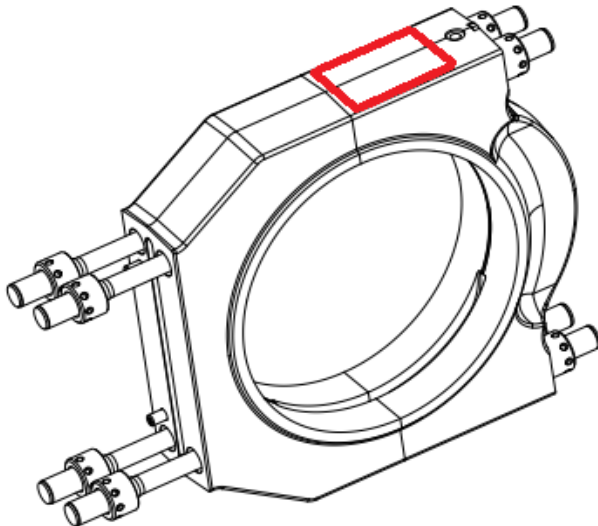


Figure 25. The planned location for W32 Conrod Module UII.

Alternative:

UII-Sticker attached to a magnetic strip, and a back-up A4 paper with all the Conrod Module UIIs included in the set. Will be used if the sticker alone proves unreliable.

Pros:

- Easy to insert and remove

- Paper to ensure that UIIs get delivered even if the sticker detaches
- Easy to read with the data matrix reader
- Cheap
- Does not clutter the finished product with an extra UII

Cons:

- The magnetic strips are lost to the Conrod Factory once they are sent out.

4.4.12 W20 & W32 Piston Modules

Requirements:

- Must be easy to read at the W20 and W32 assembly cells
- Must be able to endure transportation
- Preferably removable

Selected: UII-Sticker, with a back-up A4 paper with all the UIIs included in the Piston Set (see Figure 26).

Pros:

- Easy to insert and remove
- Paper to ensure that UIIs get delivered even if the sticker detaches
- Easy to read with the data matrix reader
- Cheap
- Does not clutter the finished product with an extra UII

Cons: None



Figure 26. Piston Module UII placement is the same for both W20 and W32 engines.

Alternative:

Dot Peen Marking the UII on the Piston

Pros:

- Endures transportation,
- Easy to read with the data matrix reader

Cons:

- Clutters the finished product with an extra UII
- Laborious to insert

4.5 Initialization of Traceability

The original plan for traceability initialization was to start from the beginning of the W20 connecting rod production process and piece by piece activate more parts to be traced by traceability. The reason for the staggered approach to initialization was to minimize the possibility of errors, both human and technology related.

Eventually, all components with connection to the QDMS database are to be traceable with traceability.

The plan was that once the W20 production was going smoothly, the W32 traceability would be initialized in a similar manner. In the future, once the W32 traceability was also working as intended, the traceability for W31 products could be activated.

The Traceability Project was initialized ahead of schedule on the W20 connecting rods due to communication error with subcontractor. Wärtsilä received gudgeon pin bearings that had the UIIs inscribed on them already, and thus was forced to start using traceability on the W20 connecting rods. It was set in the company policy that no parts with UIIs should be put to production without them being tracked by the Traceability Project.

4.5.1 Washing Machine

The initialization started in September in the middle of the production cycle, starting from the washing machine, where the gudgeon pin bearings are linked to complete connecting rods. The initialization started when the Connecting Rod Factory ran out of non-UII inscribed gudgeon pin bearings and was forced to start using the ones with the UII.

The initialization was executed by making a thorough instruction manual on the whole process at the washing machine and providing the employees with proper training on using the new equipment (see Appendix 1). Once the assigned employee was done with the process, it was verified that everything had worked as intended by checking the product material structures from SAP.

4.5.2 W20 Assembly

The next step in the Traceability Project initialization was to include Piston Module UIIs and to link the complete connecting rod to that. It was done by making a thorough instruction manual on the whole process at W20 assembly station and providing the employees with proper training to use the new equipment (see Ap-

pendix 2). Once the assigned employee was done with the process, it was verified that everything had worked as intended by checking the product material structures from SAP.

In November the old manufacturing line was shut down and the transition towards the new robotic manufacturing line was started, hence all the manufacturing at the Connecting Rod Factory was stopped. The assembly area of the Connecting Rod Factory is still active, but they are only using non-traceable materials that have been saved in the buffer stock for the renovations of the factory.

The Traceability Project in production is put on hold until March 2016, which is when the new production line is started up. During the ramp up of the new production line, traceability is also activated on all in-house produced W20 and W32 connecting rods at the Connecting Rod Factory. Additionally, some subcontracted products, such as gudgeon pins for both W20 and W32 connecting rods, are expected to arrive with UIIs.

4.6 Specialized Products

Aside from manufacturing Piston Modules for the Main Assembly to be used in Wärtsilä's in-house engine production, the Connecting Rod Factory also provides connecting rods as special deliveries for Wärtsilä's production facilities in China and for Wärtsilä's Service branch to be used as spare parts around the world. Additionally, Wärtsilä receives fully machined connection rods from subcontractors, for which the whole SAP linking process has to be considered separately.

4.6.1 Deliveries to Wärtsilä China and Wärtsilä Service

The deliveries to Wärtsilä Service only include the connecting rod and the bearings, which means that the last UII the product receives is the Complete Connecting Rod UII that is not permanently marked on the product. This means that the Complete Connecting Rod UII for these parts has to be customized to endure heavy transportation. This was done by attaching the Complete Connecting Rod UII to the connecting rod with a cable tie (see Figure 27).

The deliveries to Wärtsilä's production facilities in China only include the connecting rod and the bearings. The connecting rods delivered to China are given a special WQDC Piston Set UII, so there is no need for special arrangements with the Complete Connecting Rod UII. The Piston Set UII is attached to the connecting rod with a cable tie (see Figure 27).



Figure 27. The cable tie holds the UII-strip in place.

4.6.2 Subcontracted Connecting Rods

The Wärtsilä subcontractors have agreed to provide the connecting rods they manufacture with UIIs for the machining, and as the forgings they use come from Wärtsilä the product Wärtsilä ends up with is exactly the same as their in-house produced ones. However, the subcontractors do not have access to Wärtsilä's SAP database, which means they cannot do the linking process by themselves.

It was thought that the best method to do the linking would be to have the subcontractor provide Wärtsilä with a list of the Forging UIIs and Machined UIIs in electronic form, for example as an Excel sheet, from which SAP could acquire the UIIs (see Table 3).

A script could be written that reads the Forging UII and the adjacent Machining UII, and it would then form a link between the two in SAP database. The whole process would take a few seconds per shipment of products, as opposed to potentially taking hours of work if done manually.

Table 3. An example of a table with the information required from subcontractors.

ConRod#	Forging UII	Machined UII
11111	3739#15A#C#S#3M3C123ABS54321	21575#15B#C#S#11111
11112	3739#15A#C#S#3M3C123ABS54322	21575#15B#C#S#11112
11113	3739#15A#C#S#3M3C123ABS54323	21575#15B#C#S#11113
11114	3739#15A#C#S#3M3C123ABS54324	21575#15B#C#S#11114
11115	3739#15A#C#S#3M3C123ABS54325	21575#15B#C#S#11115
11116	3739#15A#C#S#3M3C123ABS54326	21575#15B#C#S#11116
11117	3739#15A#C#S#3M3C123ABS54327	21575#15B#C#S#11117
11118	3739#15A#C#S#3M3C123ABS54328	21575#15B#C#S#11118
11119	3739#15A#C#S#3M3C123ABS54329	21575#15B#C#S#11119
11120	3739#15A#C#S#3M3C123ABS54330	21575#15B#C#S#11120
11121	3739#15A#C#S#3M3C123ABS54331	21575#15B#C#S#11121
11122	3739#15A#C#S#3M3C123ABS54332	21575#15B#C#S#11122
11123	3739#15A#C#S#3M3C123ABS54333	21575#15B#C#S#11123

Another idea that was considered was printing the UIIs side by side on an A4 paper to be manually read with the data matrix reader, but it was discarded early on for being extremely laborious and for having a high chance of human error during linking process (see Table 4).

Table 4. An example of a printout of UIIs from subcontractor to Wärtsilä

ConRod#	Forging UII	Machined UII
11111		
11112		
11113		
11114		
11115		
11116		

5 THE NEW PRODUCTION LINE

The production line at the Connecting Rod Factory is undergoing some major changes. The old manufacturing line is going to be replaced by a robotic manufacturing line, where robots handle most of the work stages that were previously done by manual laborers. All W32 connecting rods will be manufactured using the robotic line, while W20 connection rod manufacturing will remain mostly the same as in the old system.

The new layout for machining area is complete. The new layout for the assembly area is still in the making, but the operation of the area stays the same as in the old system, even if the location of the machinery is different (see Figure 28 and Figure 29).

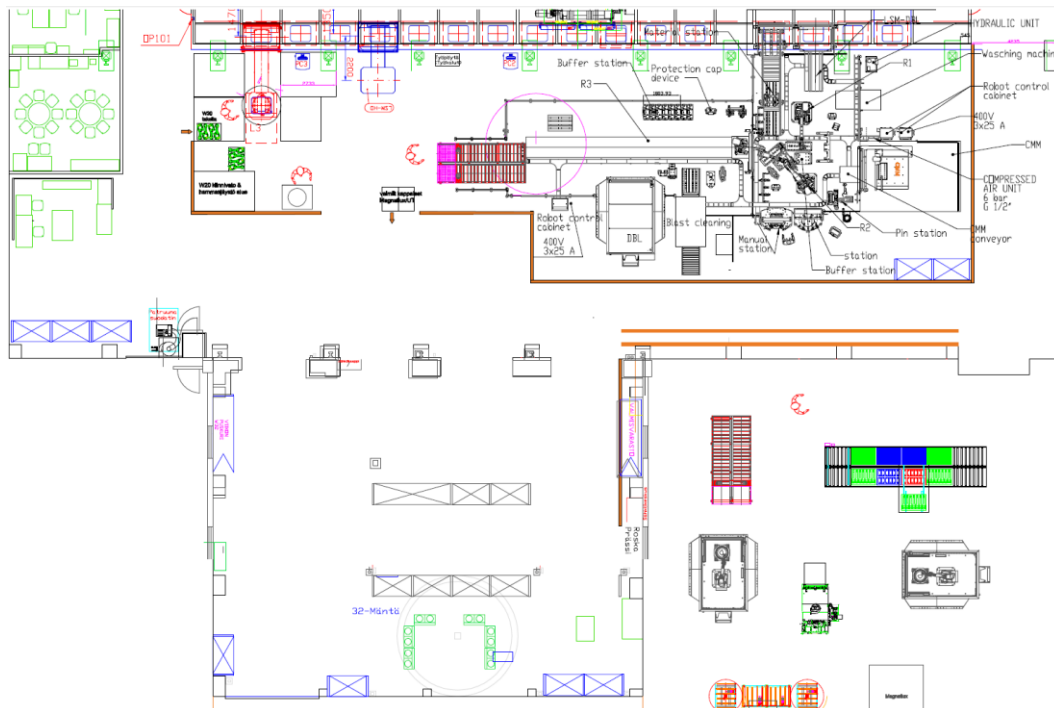


Figure 28. The new layout for Connecting Rod Factory. Work still in progress.

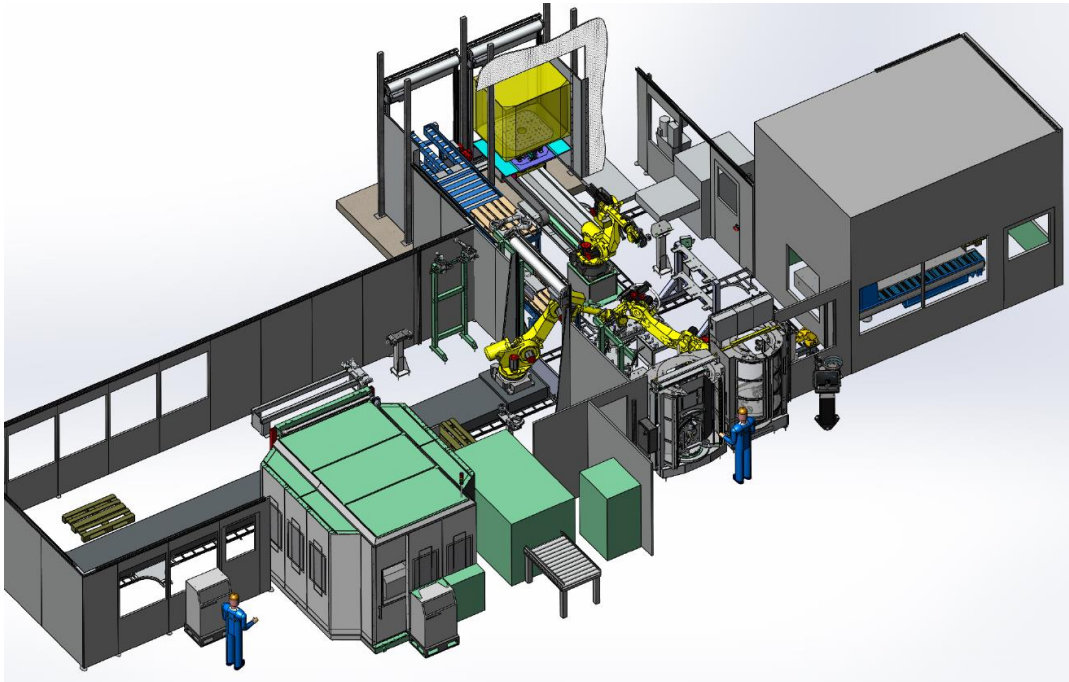


Figure 29. 3D model of the robotic manufacturing cell.

5.1 Improved Product Elevator

The improved product elevator is a part of the new system called Flexible Manufacturing System, FMS. It is equipped with sufficient intelligence to operate independently once it knows what it needs to produce; it can prioritize product manufacturing to most efficiently produce the parts that are needed.

New features of the improved product elevator include the ability to communicate with the SAP database and the robot cell. The product elevator is also used as a storage for the unfinished connecting rods, and because of its communication with the SAP database, it knows exactly which parts are held where. This enables the robotic cell to call in specific parts and allows it to independently mark and link UIIs of the products it works on.

5.2 W32 Connecting Rods

The W32 Connecting Rod Forgings, both upper and lower parts, are fed into the product elevator. The feeding process involves a user reading the Forging UII

with the matrix code reader to inform the product elevator of the parts it is about to receive. The W32 upper part pallet always has 4 forgings, and the lower part pallet has 10 forgings; 5 middle parts, 5 lower parts (see Figure 30 and Figure 31). The system interface guides the user on which part to read to reduce the risk of human error.



Figure 30. Pallets for W32 lower part forgings.



Figure 31. Pallet for W32 upper part forgings.

Before the beginning of the machining, for both upper and lower parts, a production order is opened. This creates a Machined UII that the robot inscribes on the product. The Machined UII is linked automatically to the Forging UII, which is made possible by the product elevator communicating with the robotic cell and knowing which parts it is feeding there. The only difference between upper and lower part machining process is that the lower part is two separate blocks that have to be taken outside the robotic cell twice: to be fastened together for finish machining and to be separated after it is done. This allows for a quick visual check of the lower part during the machining process.

Once the machining and inscribing is done, the robots take the piece through a washing machine, an automated measuring process, shot peening and deburring. When those are done, the production order is automatically closed and robot takes the product to a conveyer belt that takes the piece to a manual laborer who visually checks the quality of the product and takes the parts to magnetic particle inspection.

From the magnetic particle inspection the parts are taken to the washing machine in sets of 6. For upper parts gudgeon pin bearings are attached. At the washing machine, a production order is opened creating the W32 Complete Upper Part UIIs that are printed out and attached to the upper part with a magnetic strip. The gudgeon pin bearing UIIs and the Upper Part Machined UIIs are linked to the Complete Upper Part UIIs with the matrix code reader. The production order is closed and the upper parts are taken to the W32 assembly. The lower parts simply get washed and move on to the assembly without any additional work stages.

At the assembly two production orders are opened creating the W32 Piston Module UII and the W32 Conrod Module UII. Once all the UII links are done, the assembled products are sent forward in production to the Main Assembly.

The UIIs linked during the assembly will be introduced in a staggered manner, one at a time, to reduce the risk of human error during the linking process. However, when traceability is fully activated at the Connecting Rod Factory, all of the

following UIIs will be linked to the Piston Module UII during the assembly process:

- Complete Upper Part UII
- Piston UII
- Piston Ring UIIs
- Gudgeon Pin UII
- Connecting Rod Screw UII
- Connecting Rod Nut UII

The following UIIs will be linked to the Conrod Module UII:

- Lower Part Machined UII
- Connecting Rod Screw Long UII
- Big End Bearing Lower UII
- Big End Bearing Upper UII

5.3 W20 Connecting Rods

The new production line does not change much for the W20 production methods. The production is still done in the same way as it has been before, only the location and layout is different. However, the full activation of traceability for in-house produced parts adds some tasks for the employees working on the connecting rods.

First, the W20 Connecting Rod Forging UII is read to inform the product elevator of the product it is about to receive. Before the machining is started, a production order is opened creating a Machined UII for the product. After the second stage of machining, the W20 Connecting Rod Machined UII is marked on the connecting rod with the marking machine. The marking machine has its own data matrix reader and it receives the correct UII to inscribe from the production order of the machined connecting rod. This also automatically links the two UIIs in the database.

Once the machining is done, the product goes through magnetic particle inspection and then to washing machine, where gudgeon pin bearings are attached. Another production order is opened and the Complete Connecting Rod UIIs are printed out and attached to the connecting rods with magnetic strips. The gudgeon pin bearings are linked to the complete connecting rod and the production order is closed. From there, the connecting rod is sent to W20 assembly, where a production order is opened creating W20 Piston Module UII, which is attached to the piston with a sticker.

The UIIs linked during the assembly will be introduced in a staggered manner, one at a time, to reduce the risk of human error during the linking process. However, when traceability is fully activated at the Connecting Rod Factory, all of the following UIIs will be linked to Piston Module UII during the assembly process:

- W20 Complete Connecting Rod UII
- Connecting Rod Screw UII
- Connecting Rod Nut UII
- Piston UII
- Piston Ring UIIs
- Gudgeon Pin UII

6 CONCLUSIONS

All in all, the Traceability Project ran smoothly for the duration of my thesis. There were weekly meetings regarding the project, where the stages and schedules of the project were discussed and planned. The schedule was fairly flexible and changes to it were regular.

The project required a lot of communication between different departments. Sometimes the communication was lacking, as there were situations where there was confusion on who was working on what. Aside from that, the parts of the project concerning the Connection Rod Factory, and my thesis, worked really well.

Connecting Rod Factory employees have been mainly supportive of the project, as they understand the benefits it has for the company and them in the long run. The project at the Conrod Factory has mainly been led by the factory's development engineer, whose contribution to the project, and his help with my thesis, has been invaluable.

6.1 Problems and Solutions

Some problems encountered during the ramp up of the Traceability Project were problems with the software of the data matrix reader, human errors during production and cumbersome SAP functionalities.

6.1.1 Data Matrix Reader

The traceability software for the data matrix reader was created by Wärtsilä Italy. It is clumsy to customize, but due to it being a Wärtsilä product, the communication to apply required changes has been managed well and in a timely fashion.

One of the biggest issues with the reader was when it ran out of battery, all the programs installed and settings applied would disappear: Wi-Fi settings, traceability software and reading settings. A solution for the traceability software was found by saving the software installer into the flash memory of the device, but it is a temporary solution as it is unnecessarily complicated and laborious to execute.

For Wi-Fi, a rather complicated procedure was required through the control panel. For the reading settings, the setting process was rather laborious, but a solution was found with the help of Cognex's customer support. It was possible to save the reading settings as a matrix code, so a paper was printed with different reading settings for different materials. Additionally, the reading settings could be saved to a computer version of the settings tool and those could be set as the new default setting for the data matrix reader (see Figure 32).

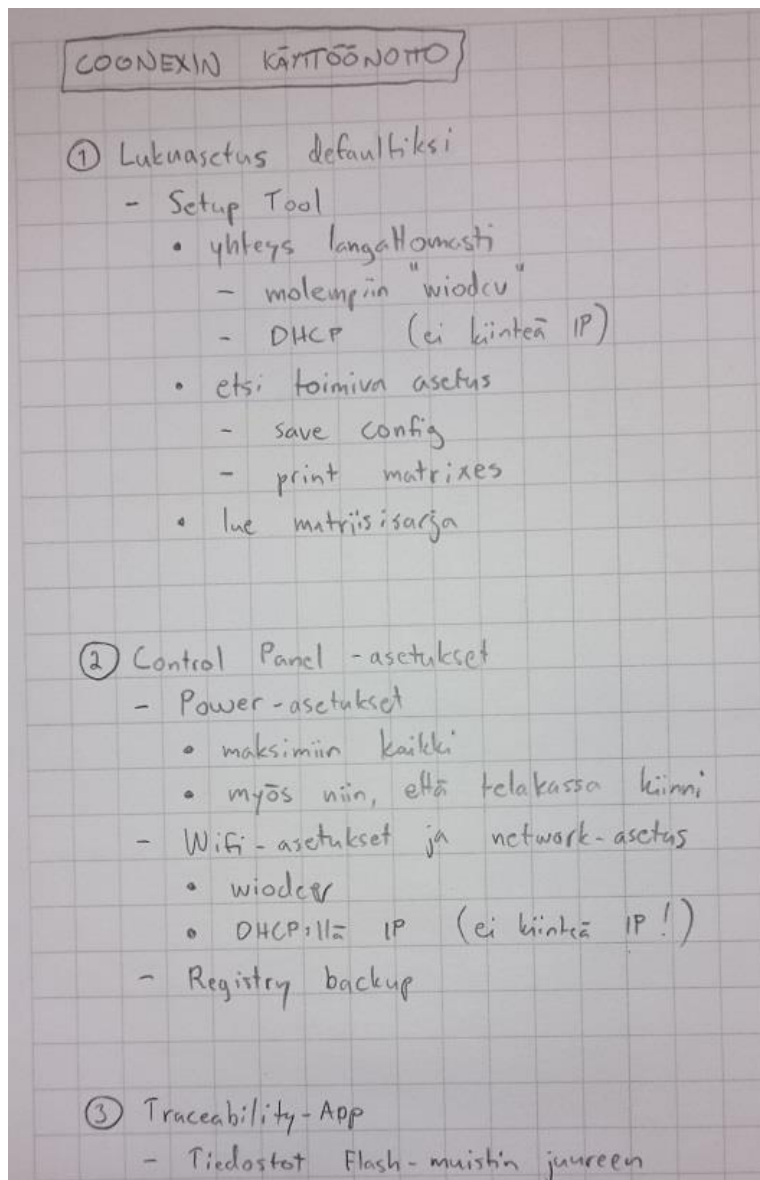


Figure 32. The procedures to set the reader settings.

6.1.2 SAP database

SAP database problems included slow response times, troublesome confirmation process to ensure that all the linkings were done correctly and the clumsiness of the process of scrapping a defective product.

Slow response times caused problems at production. The data matrix reader could sometimes take over an hour to get the correct information out of SAP, which caused bottlenecks at production. Another issue with slow response time was when a new production order was opened, it would not register in properly in SAP, leaving out the producing of UIIs needed for production. Both of these issues have been worked on by Wärtsilä's IT department, and while there has been considerable improvement, the waiting times are still sometimes up to 5 minutes, which is way too long to be acceptable.

The problems with the confirmation process have mostly to do with convenience and saving time. Currently, the confirmation process takes several minutes every single assembly has to be gone through individually, and to see the linking several different tabs have to be browsed through to finally get to the traceability confirmation window. A solution to this would be that the system provided a PDF-printout on the closing of the production order, showing all the linkings done on the products on that production order.

The clumsiness of scrapping a product refers to the functionality of the process in SAP. Currently, the scrapping process is difficult to handle through SAP, and takes several steps to achieve. Hopefully, in the future, it could be done with the data matrix reader in two simple steps:

1. Reading the code of the defective part to remove it from the material tree
2. Reading the code of the replacing part to place it in the correct spot and to link it automatically to the previous and next parts of the material tree.

6.1.3 Human Errors

A potential cause of issues with traceability is the end-user and their errors. Errors are often done due to insufficient training, negligence or because of an outside distraction. In traceability, there are few critical places where negligence can cause big errors that can potentially go through entire production, all the way to the customer without ever being noticed.

One of these places is the loading of the forgings into the product elevator. The forgings have to be read in correct order for the system to understand which part is which. The system expects the user to read the UIIs in the correct order from the one nearest to it, to the one furthest from it. If an error is made there, the system will not be able to catch it, but expects that they are read correctly. Then, when the forging goes from machining to the robot for the marking process, the system links the Machined UII to the wrong Forging UII. After that, it is very likely to go through the entire production chain without anyone noticing the error, only to be found out if there are issues with it in the engine and Wärtsilä Service has to read the forging UII.

Other potential user errors include accidentally reading the wrong UII, or completely forgetting some component from the linking process. These issues will be addressed with the upcoming MES-project, but until it is finished, there are no fail-safes to prevent issues like this from happening. Currently, the products are manually checked to ensure that all parts have been linked, but it is laborious and time consuming task that should not be necessary in the future.

6.2 The Way Forward

In the future, Wärtsilä will activate the Traceability Project at other departments, move onto using a MES-interface on SAP, begin traceability on the W31 engines, remove unnecessary work stages and add more components to traceability.

Currently, the Connecting Rod Factory has been the main testing ground for the Traceability Project at Wärtsilä. However, as the project is intended to be global, it will be activated in other factories around the world in a controlled manner,

starting from Wärtsilä Finland's Cylinder Head Factory that has had its first touches with the Traceability Project this November, and Wärtsilä Italy, which has been working on the software used in the project. The other factories will follow suit with the experiences of the Connecting Rod Factory to smoothly adapt the traceability process.

The MES Project, in addition to making SAP more user-friendly, provides the Traceability Project with fail-safes to prevent user errors. Hopefully, most of the issues with SAP get fixed with the MES Project, but those that do not require some additional attention to provide a user-friendly and trouble-free environment to work in.

The initialization of the W31 engines to traceability should provide to be quite easy, as the production is fairly identical to the W32 engines. Once the employees in production are used to the W32 traceability, the inclusion of the W31 traceability should not cause any additional issues, as it follows the same pattern as W32 engines do.

The future plan is to add as many components as viable to traceability. Once the employees are familiar with the traceability process, adding more components to it is only a matter of slightly altering the work routine. Of course, whenever new components are added, the problem of employee forgetfulness arises, but the working methods should already be routine to minimize the risks. Also, as the traceability process becomes routine, Wärtsilä can start removing some of the old markings on the components as unnecessary, since they are all included in the UIs, making the products more aesthetically pleasing.

Additionally, as traceability and the UIs become the norm in all stages of engine production at Wärtsilä, the plan is to automate many of the measurements now done by hand. This is made possible by the link the products have to SAP, making the measuring machines able to directly add the information they gather to QDMS without the need of human guidance. Also, as traceability becomes active on all components, they are directly linked to SAP by the data matrix reader, so there is no more need to manually enter all the components used during assembly. This

not only speeds up the process, but also almost completely removes the possibility of human error. So even though the traceability only adds more work stages in the beginning, once it is properly established, it will reduce the work stages considerably.

REFERENCES

- /1/ Wärtsilä in brief. Annual Report 2014. Accessed 5.10.2015
<http://www.wartsilareports.com/en-US/2014/ar/this-is-wartsila/this-is-wartsila/>
- /2/ Wärtsilä Mission & Vision. Wärtsilä Web Pages. Accessed 26.11.2015
<http://www.wartsila.com/usa/about/mission-vision>
- /3/ Wärtsilä Marine Solutions. Wärtsilä Web Pages. Accessed 26.11.2015
<http://www.wartsila.com/marine/applications>
- /4/ Wärtsilä Solutions 2015-2016 Booklet. Accessed 26.11.2015
<http://cdn.wartsila.com/docs/default-source/marine-documents/brochure-marine-solutions-2015.pdf?sfvrsn=19>
- /5/ Wärtsilä Energy Solutions. Wärtsilä Web Pages. Accessed 26.11.2015
<http://www.wartsila.com/energy>
- /6/ Smart Power Generation. Accessed 26.11.2015
<http://www.smartpowergeneration.com/>
- /7/ Wärtsilä Services. Wärtsilä Web Pages. Accessed 26.11.2015
<http://www.wartsila.com/services>
- /8/ Traceability. Wikipedia. Accessed 26.11.2015
<https://en.wikipedia.org/wiki/Traceability>
- /9/ Traceability Implementation DCV_29.9.2015.pptx. Wärtsilä Intranet. Accessed 27.11.2015
- /10/ Traceability_Marking_Instruction_042014_draft.docx. Wärtsilä Intranet. Accessed 5.11.2015

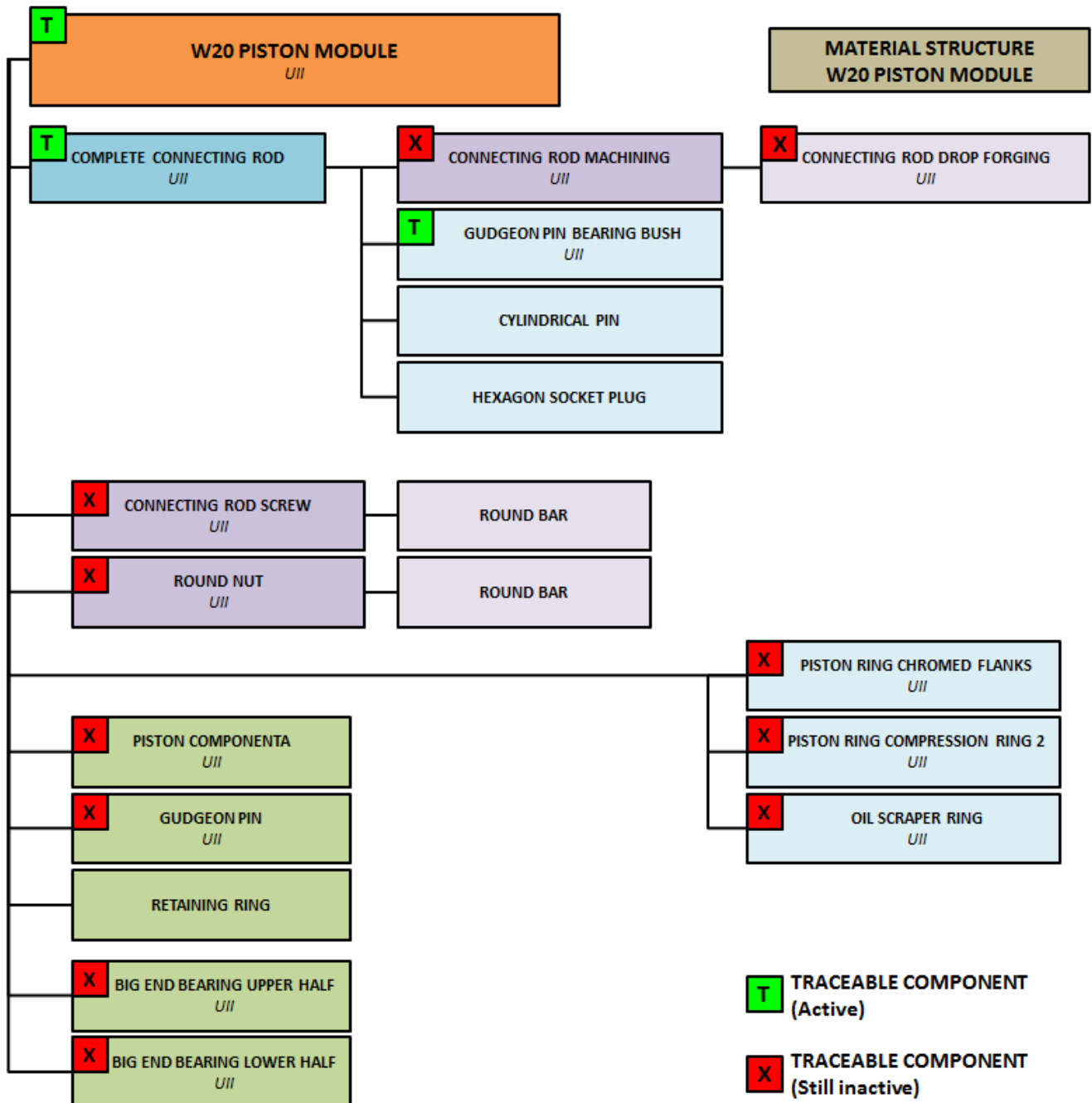
APPENDIX 1

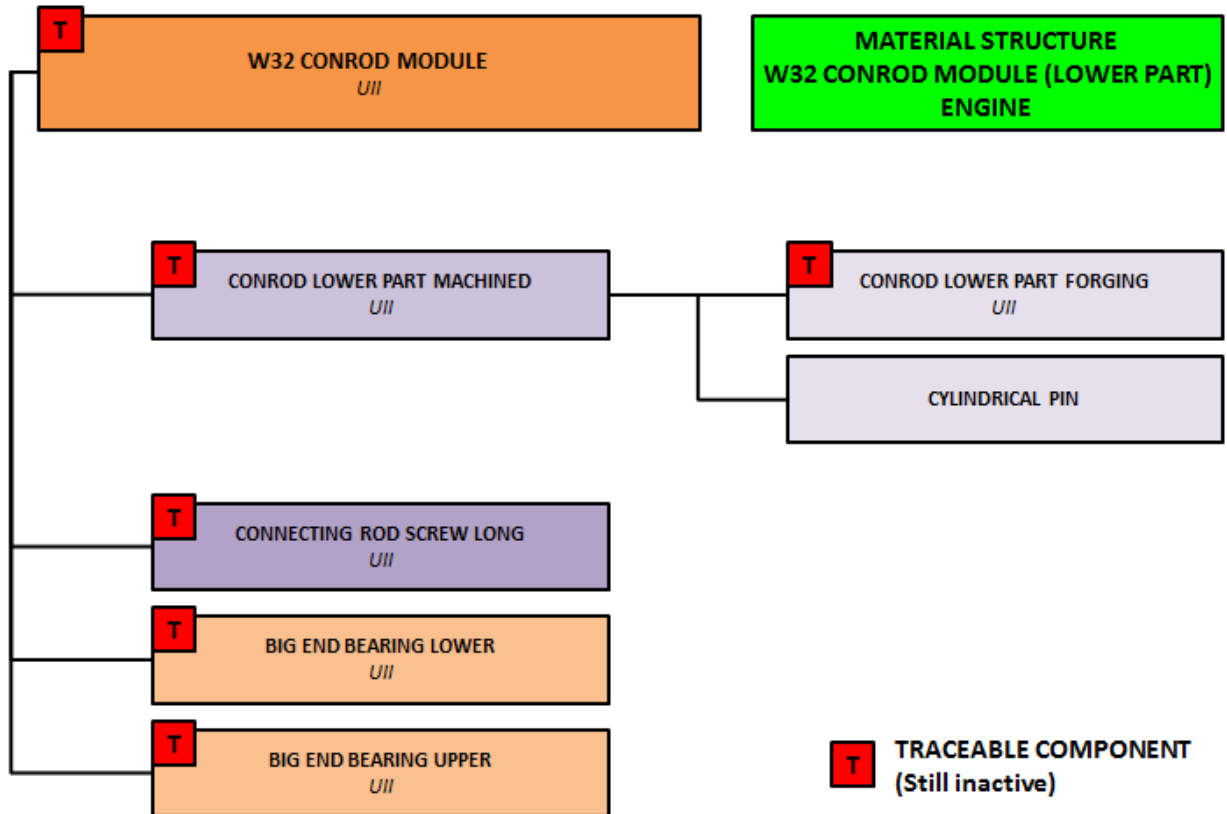
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Material structure trees for assemblies done at Connecting Rod Factory.





**MATERIAL STRUCTURE
W32 CONROD MODULE (LOWER PART)
SERVICE**

